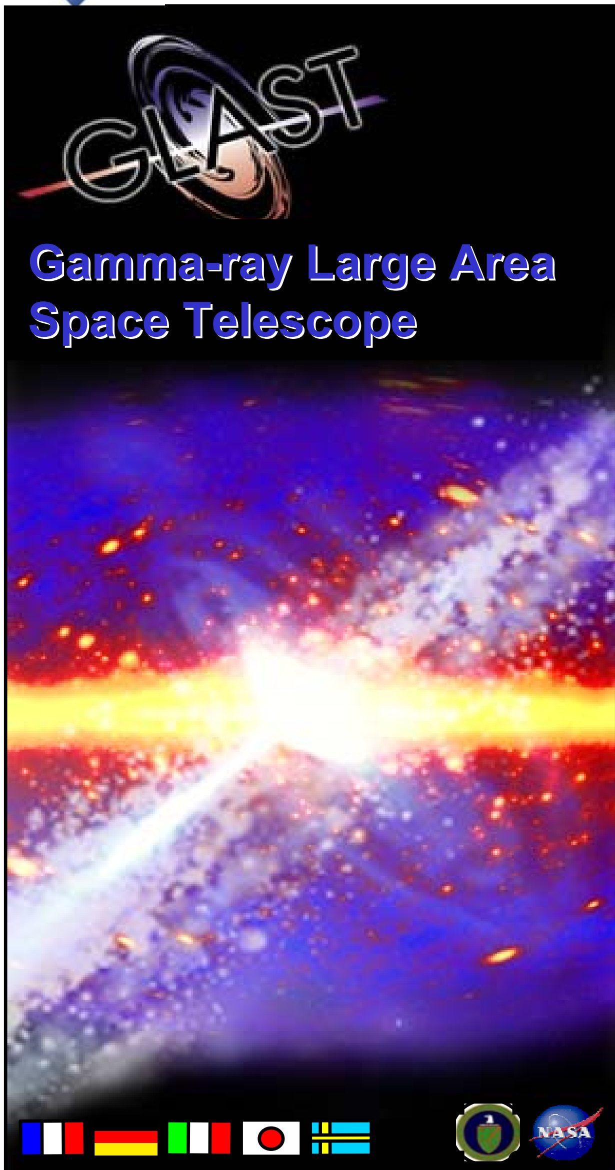


The GLAST Gamma-Ray Telescope Mission

Robert P. Johnson
Santa Cruz Institute for Particle Physics
Physics Department
University of California at Santa Cruz

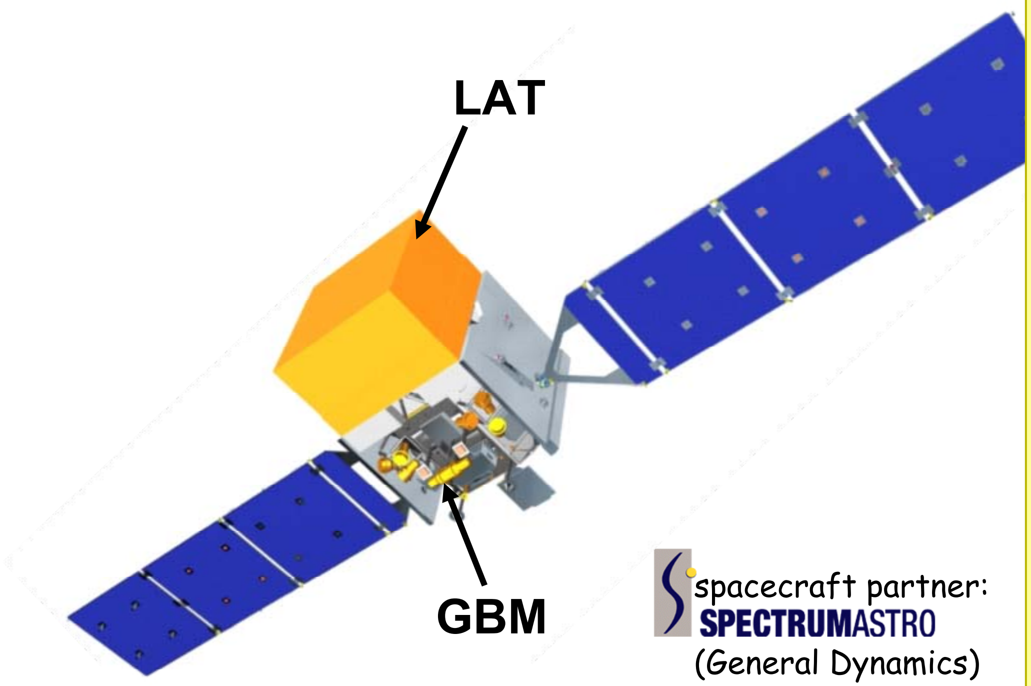
GLAST LAT Tracker Subsystem Manager
Representing the LAT Collaboration
rjohnson@scipp.ucsc.edu

See: http://www.glast.gsfc.nasa.gov
and links therein

Gamma-ray Large Area Space Telescope

GLAST Gamma-Ray Observatory:

- LAT ~20 MeV and up
- GBM 20 keV to 20 MeV
- Spacecraft bus

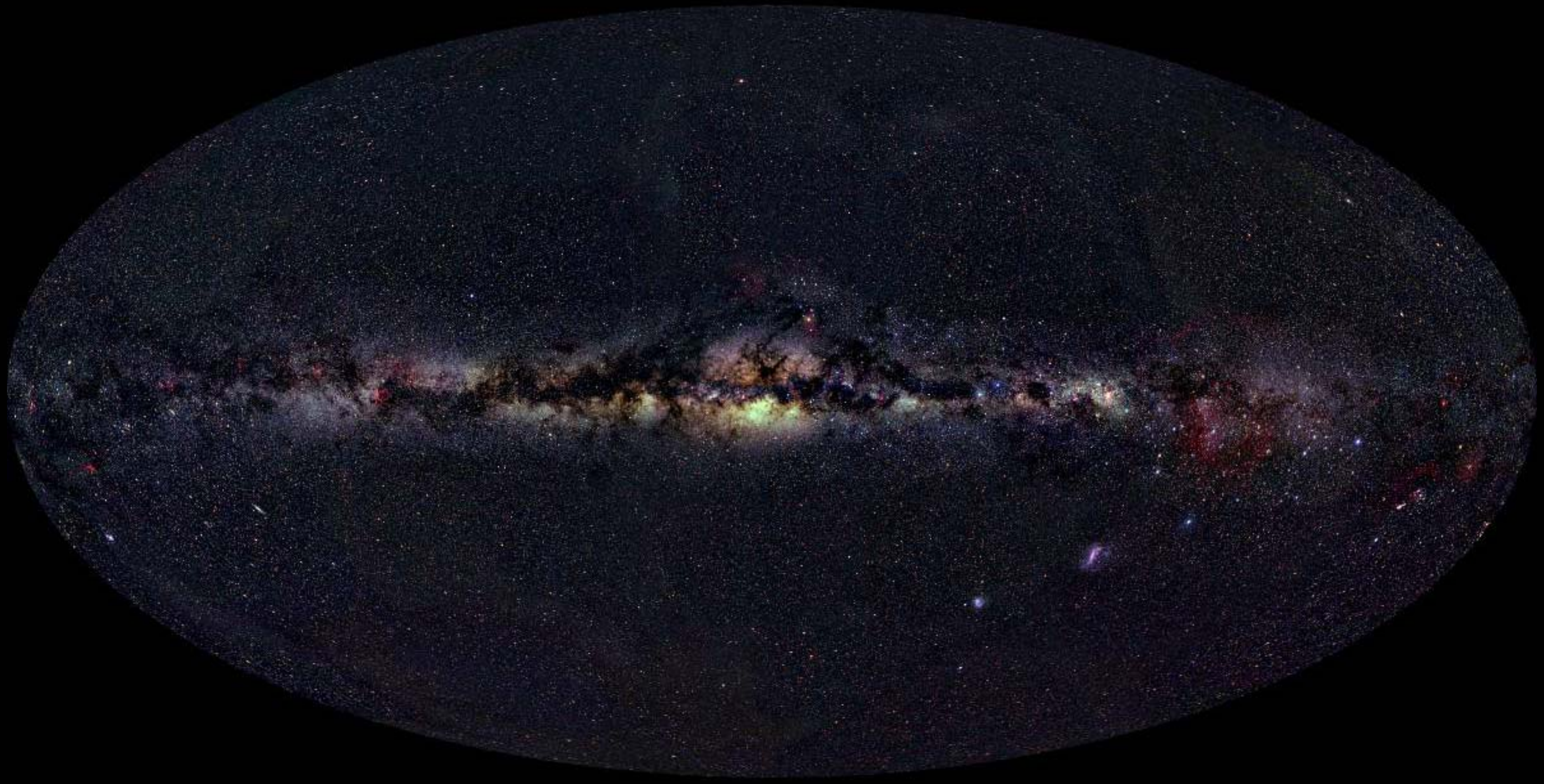


spacecraft partner:
SPECTRUMASTRO
(General Dynamics)

Why study HE gamma rays?

- Produced only by non-thermal processes around special and interesting astrophysical objects.
- Unlike cosmic rays, they travel in straight lines from their sources.
- Probe cosmological volumes and the center of the Milky Way.
- Individual photons are readily detected.

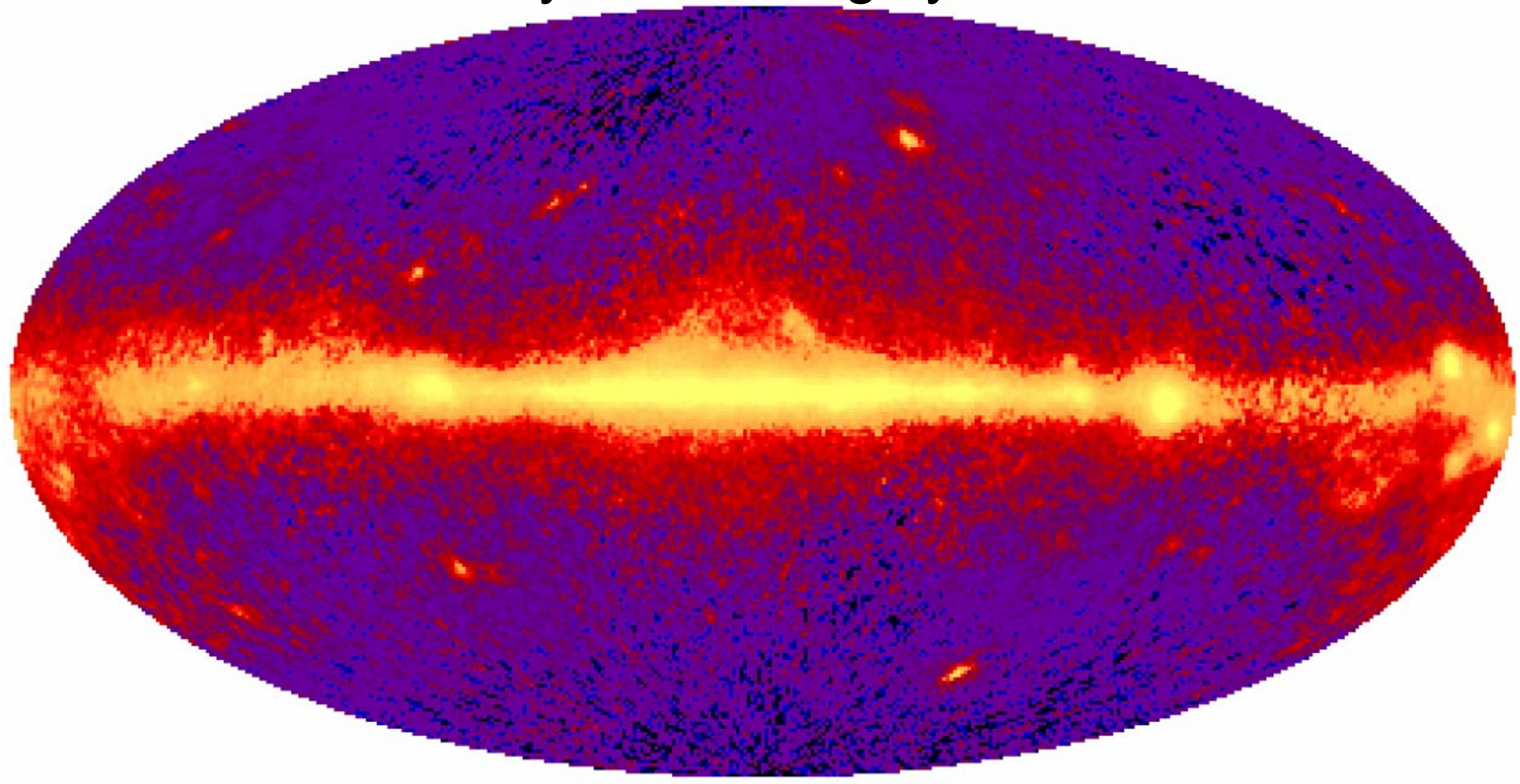
All Sky View in Galactic Coordinates



All Sky in Gamma Rays

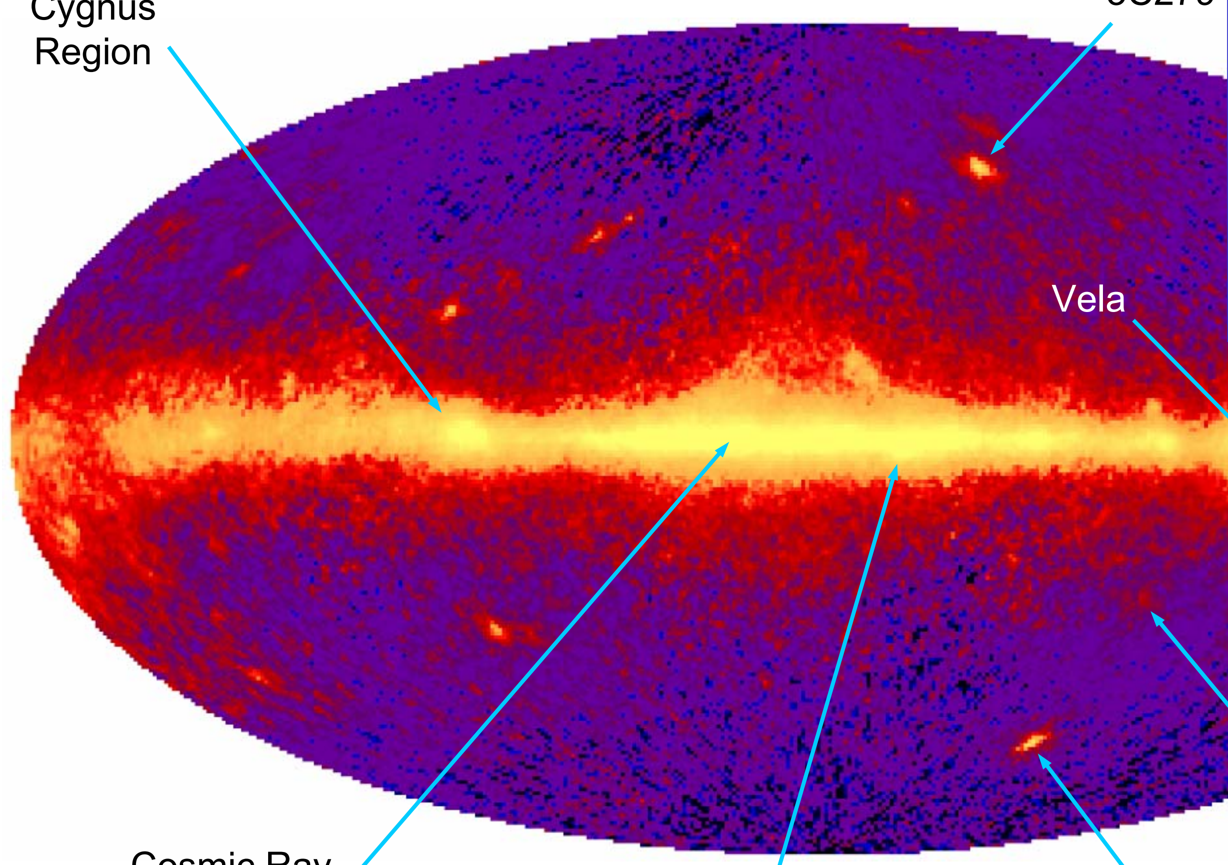
Relatively few point sources.

Many of them highly variable.



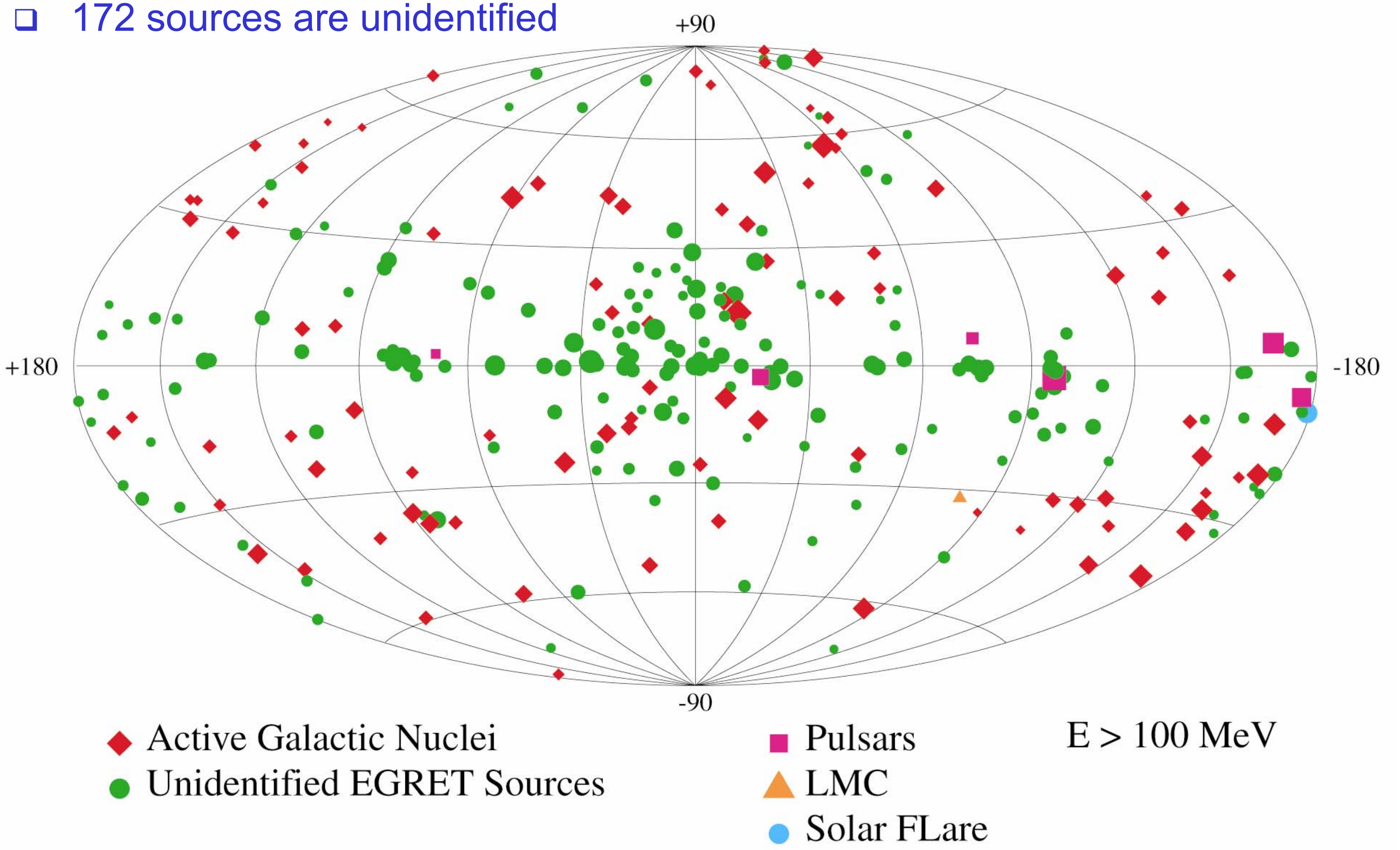
Scientific Heritage: CGRO-EGRET

EGRET All-Sky Map (E> 100MeV)



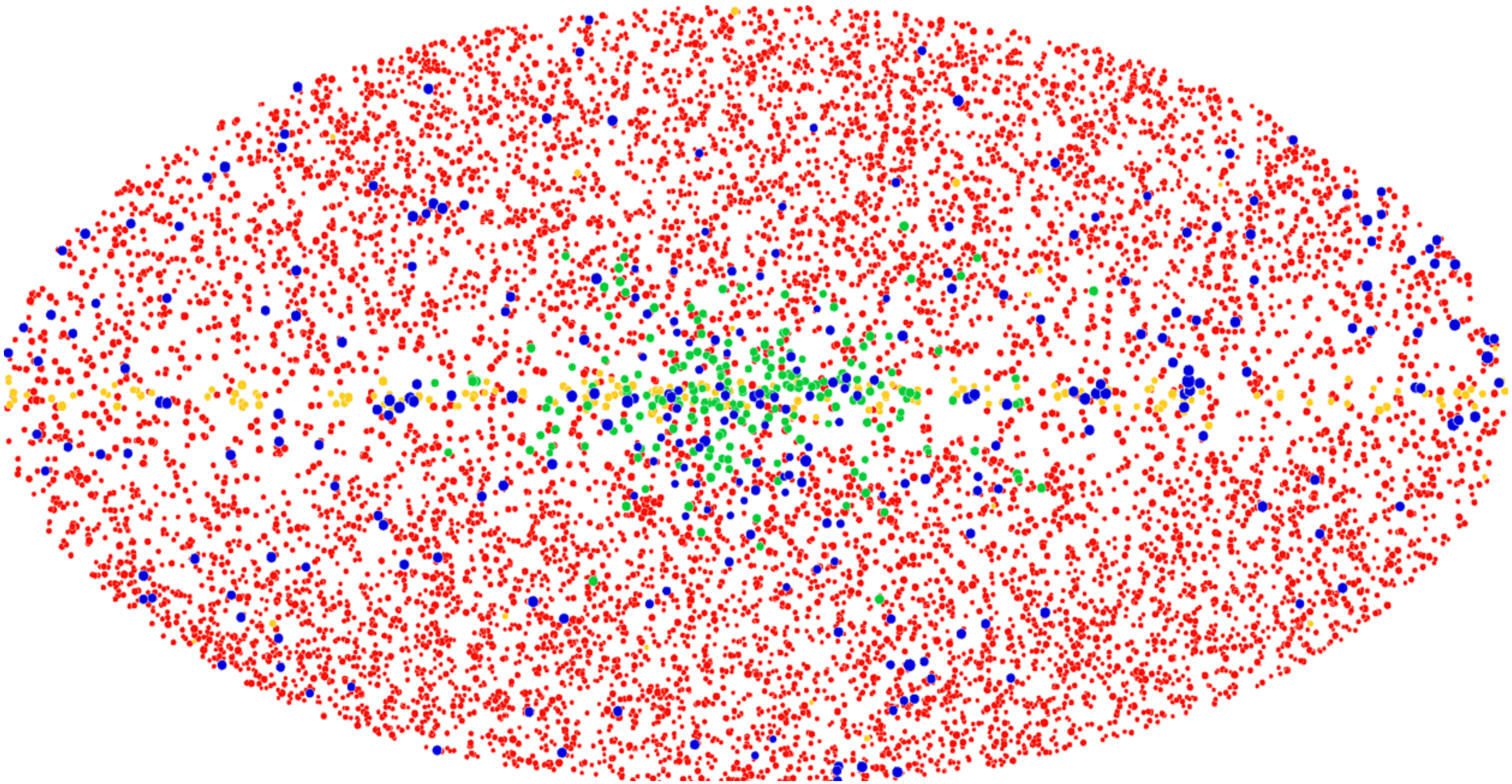
3rd EGRET Source Catalog

- 271 sources
- 172 sources are unidentified



LAT Source Catalogs

5σ sources from a simulated
1-year all-sky survey.



LAT Catalog: ~10,000 sources expected.

GRB, AGN, 3EG + Gal. plane & halo sources

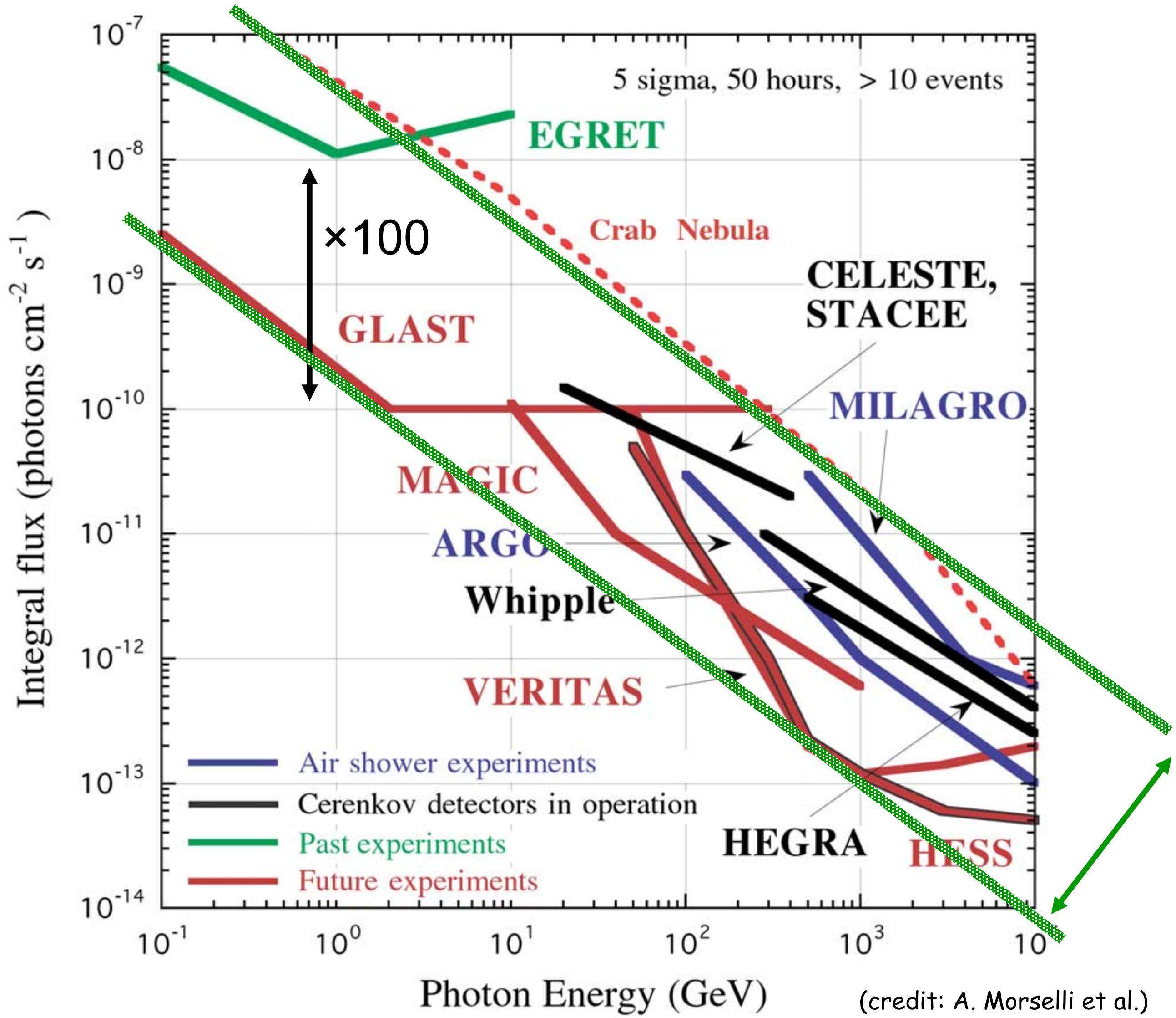
GLAST LAT High Energy Capabilities

The LAT will provide a huge leap in science capability:

- >30 times improvement in source sensitivity over EGRET:
  - Large effective area: > 5 times larger than EGRET
  - Field of View (~20% of sky) 4 times greater
  - Unprecedented angular resolution for this wavelength band
    - 3 times better than EGRET for E > 1 GeV
- Broadband: 4 decades in energy
  - Including the unexplored region E > 10 GeV
- Small deadtime of 25 μs; 4,000 times shorter than EGRET
- No expendables: long mission without degradation

Point-Source Flux Sensitivity

- GLAST 1-year survey
  - 5σ threshold
  - Isolated source
- As much as 100 times improvement on EGRET
- Very well matched to the new ground-based detectors, in units of “Crabs”.

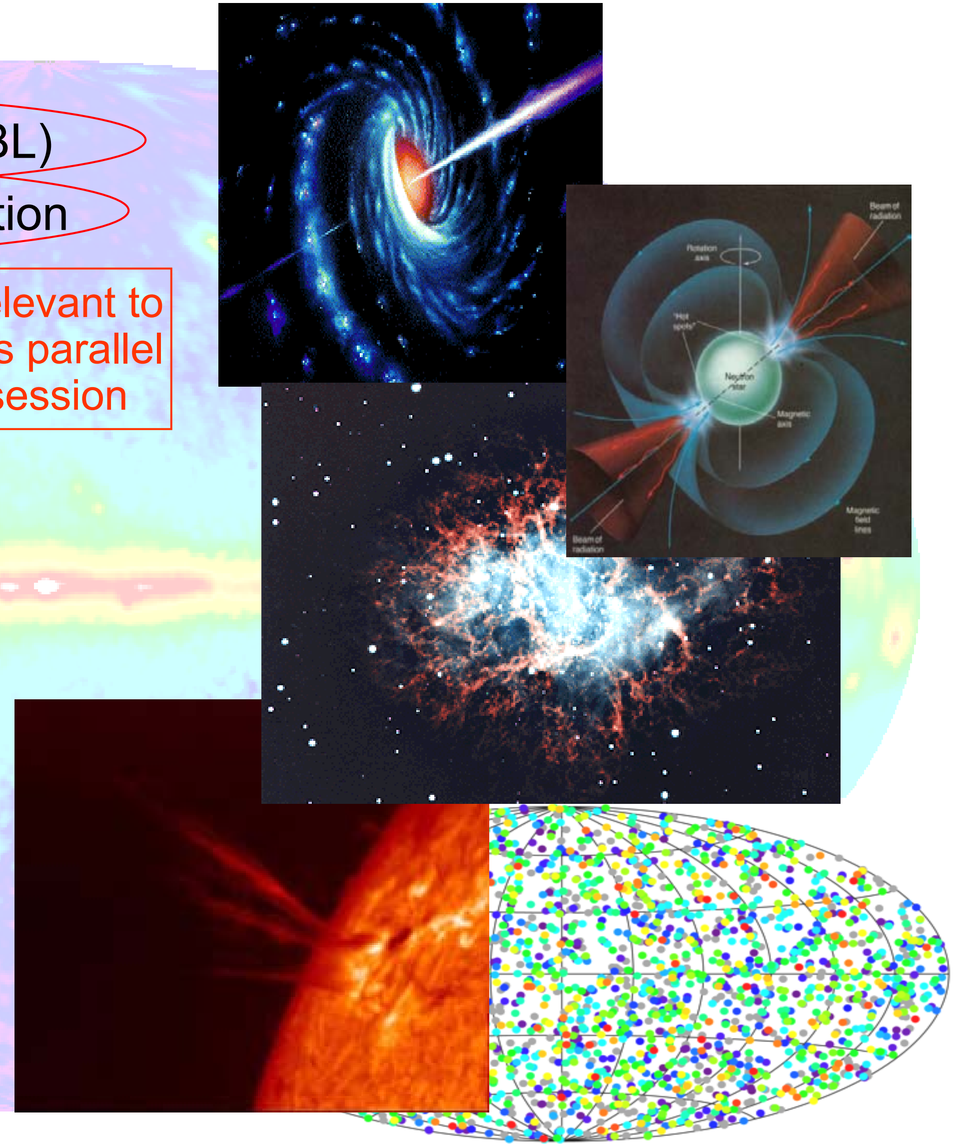


(credit: A. Morselli et al.)

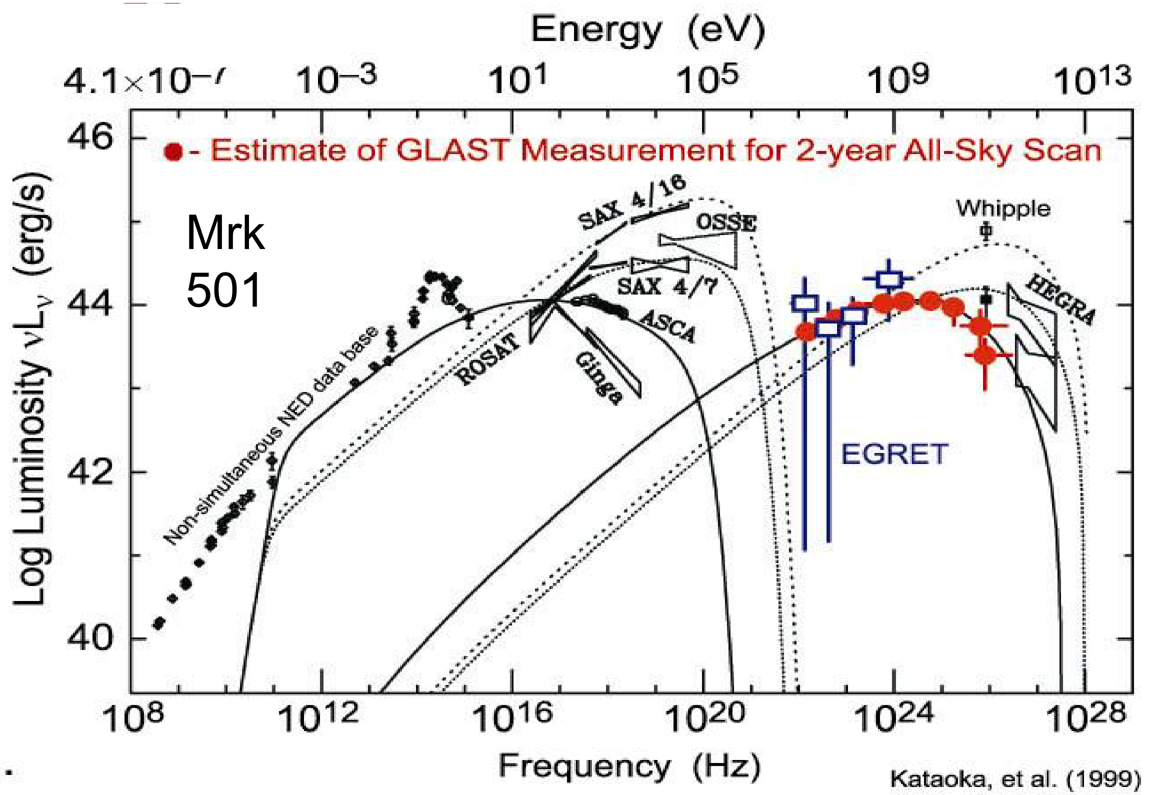
GLAST Science Opportunities

- Active Galactic Nuclei
- Extra-galactic Background Light (EBL)
- Isotropic Diffuse Background Radiation
- Endpoints of Stellar Evolution
  - Neutron Stars/Pulsars
  - Black Holes
- Cosmic Ray Production:
  - Identify sites and mechanisms
- Gamma-Ray Bursts
- Solar Physics
- DISCOVERY!
  - Identifying known sources
  - New classes of γ-ray sources?
  - Dark Matter (WIMPs)?
  - New cosmological relics?
  - Dispersion in vacuum?

Relevant to this parallel session



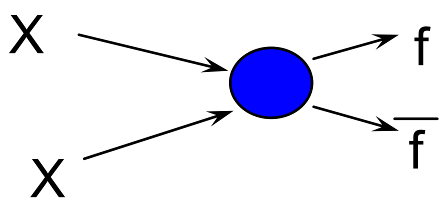
AGN Cosmology Laboratories



- Intense gamma-ray beams observable across the universe at all *z.*
- Probe Optical-UV EBL by looking at cutoff vs z
  - *High statistics* (but need *z* from optical telescopes!).
- Searches for violations of Lorentz invariance.

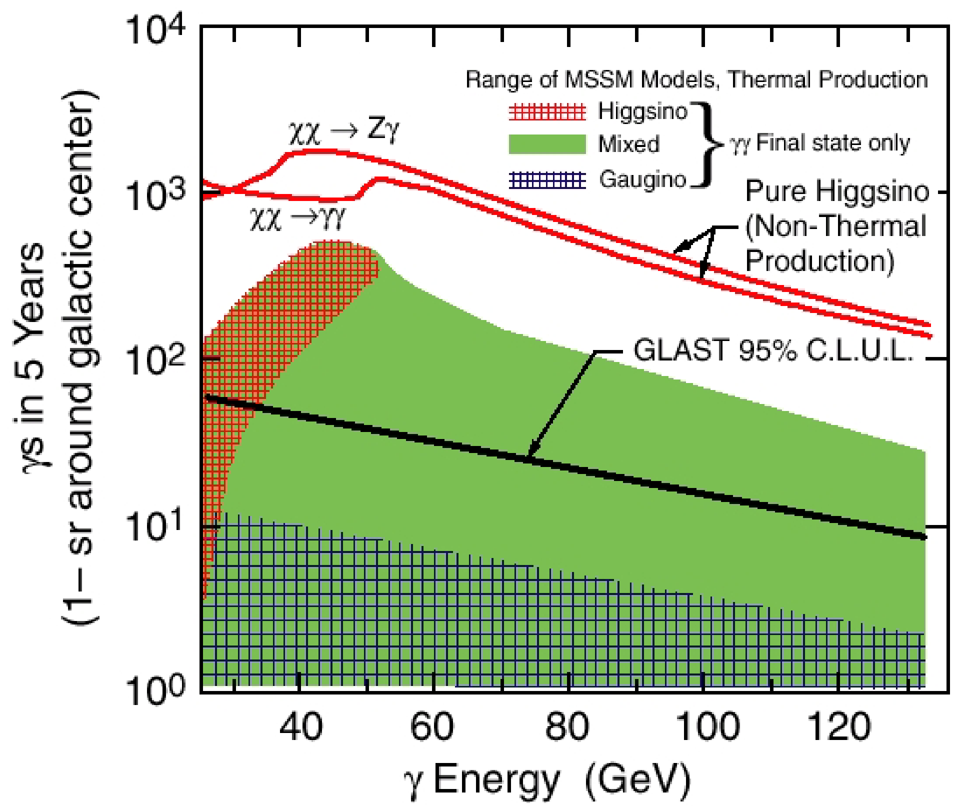
Dark Matter Searches

WIMP annihilation



- Direct searches for $\gamma\gamma$ states (lines) would give the cleanest discovery signal.
- Sensitivity to part of the space of SUSY parameters/galactic models.

- Less direct searches, such as for anomalous galactic flux, could have greater sensitivity to dark matter.
    - Some tantalizing (but inconclusive) indicators from the galactic center region (EGRET, WMAP, HESS)
    - GLAST will have far greater sensitivity than EGRET.



GLAST LAT Collaboration

United States

- California State University at Sonoma
- University of California at Santa Cruz - Santa Cruz Institute of Particle Physics
- Goddard Space Flight Center – Laboratory for High Energy Astrophysics
- Naval Research Laboratory
- Ohio State University
- Stanford University (SLAC and HEPL/Physics)
- University of Washington
- Washington University, St. Louis

France

- IN2P3, CEA/Saclay

Italy

- INFN, ASI

Japan

- Hiroshima University
- ISAS, RIKEN

Sweden

- Royal Institute of Technology (KTH)
- Stockholm University

PI: Peter Michelson (Stanford & SLAC)

- **LAT instrument fabrication and science support managed at SLAC.**
- **GLAST mission managed by NASA GSFC.**

GBM Collaboration

National Space Science & Technology Center

University of Alabama in Huntsville

NSSTC

NASA Marshall Space Flight Center

Max-Planck-Institut für extraterrestrische Physik

Michael Briggs
William Paciesas
Robert Preece

Charles Meegan (PI)
Gerald Fishman
Chryssa Kouveliotou

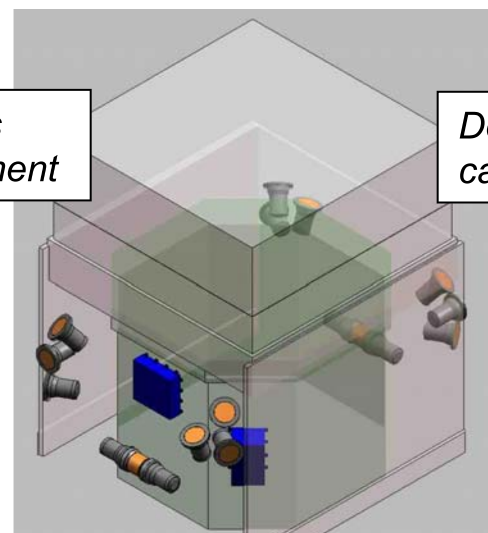
Giselher Lichti (Co-PI)
Andreas von Keinlin
Volker Schönfelder
Roland Diehl

+ Marc Kippen, LANL

On-board processing, flight software, systems engineering, analysis software, and management

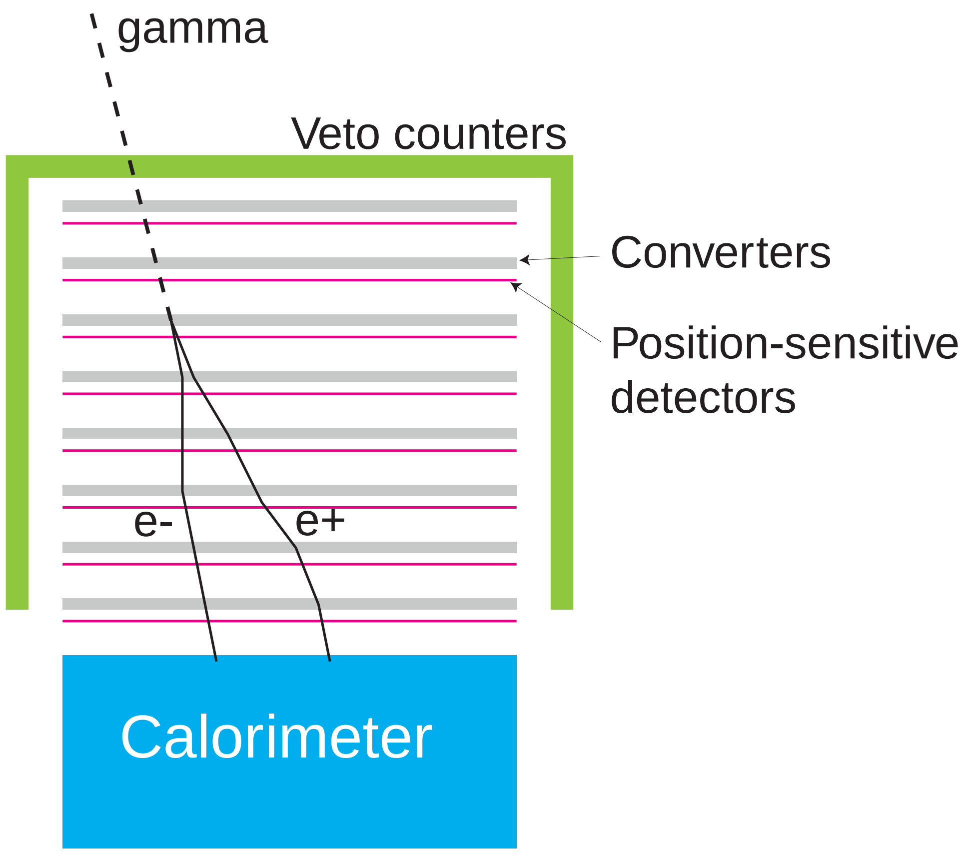
Detectors, power supplies, calibration, and analysis software

12×



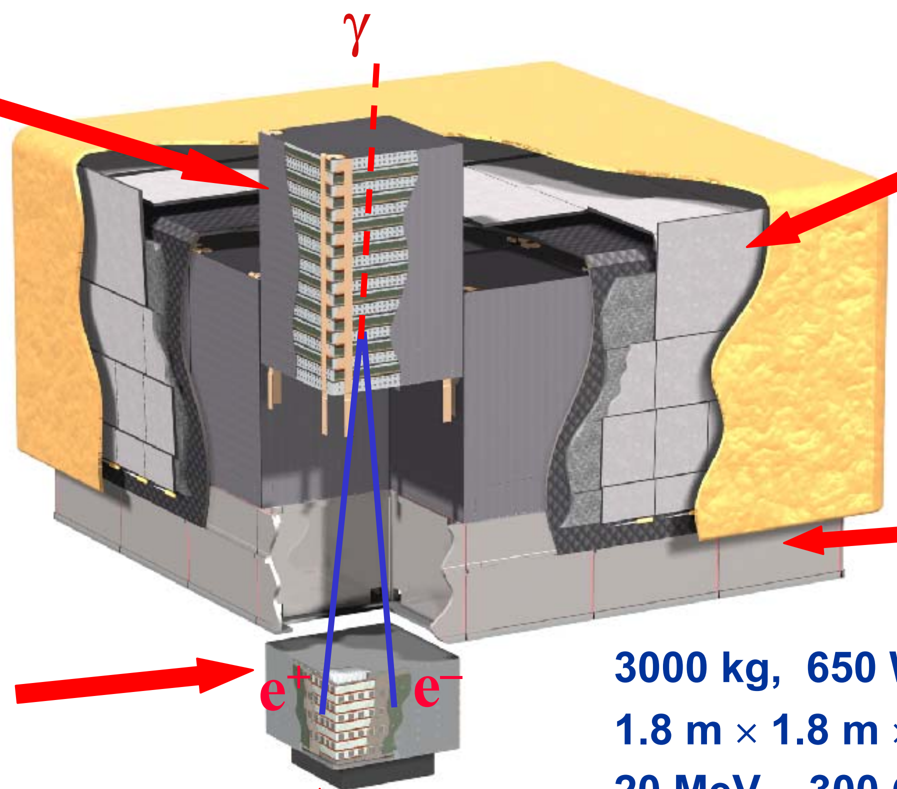
2×

Pair-Conversion Telescope Principle



- Veto counters: a signal indicates presence of a charged cosmic ray, instead of a photon.
- Tracker/Converter: heavy metal converts the photon to a positron-electron pair. The measured tracks point back to the astronomical source.
- Calorimeter: measures the photon energy

GLAST LAT Overview



Si Tracker

16 tungsten layers
36 SSD layers
Strip pitch = 228 μm
Self triggering
$8.8{\times}10^5$ channels
<160 Watts

ACD

Segmented scintillator tiles
0.9997 efficiency
Minimal self veto

Grid (& Thermal Radiators)

CsI Calorimeter

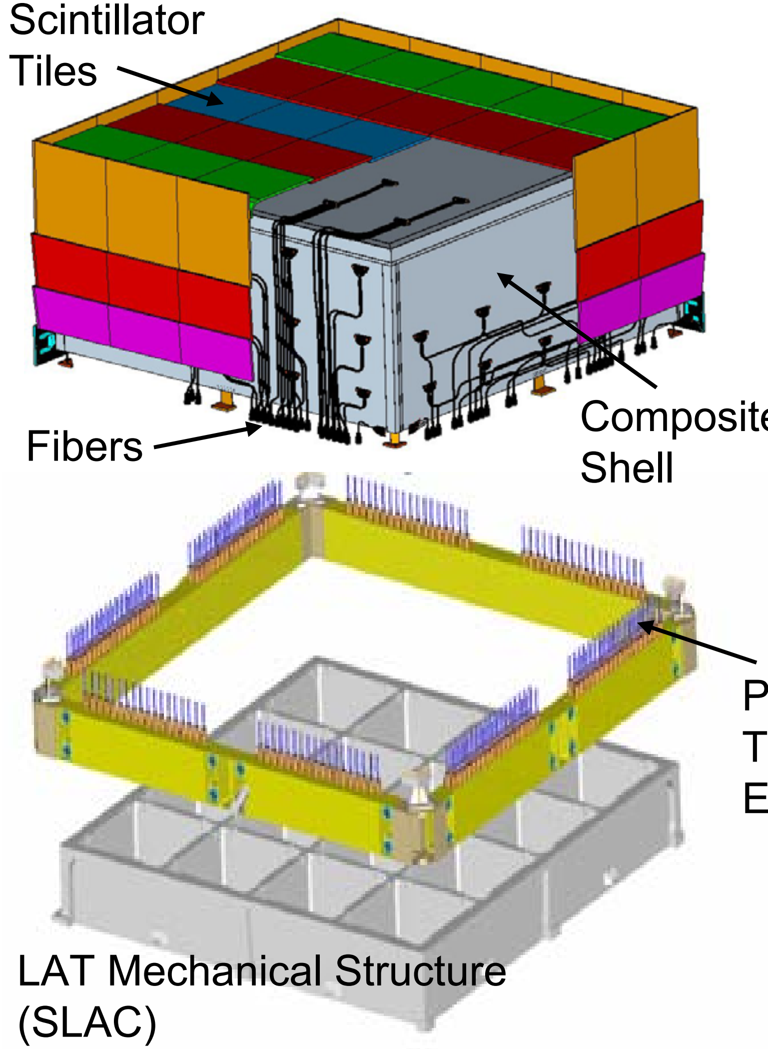
Hodoscopic array
8.4 X_0 8 × 12 bars
2.0 × 2.7 × 33.6 cm
⇒ cosmic-ray rejection
⇒ shower leakage correction

Data acquisition

3000 kg, 650 W (allocation)
1.8 m × 1.8 m × 1.0 m
20 MeV – 300 GeV

Mega-channel particle-physics detector *in orbit:*
⇒ Low power (<650 W)!
⇒ Extensive data reduction on orbit!
⇒ No maintenance!

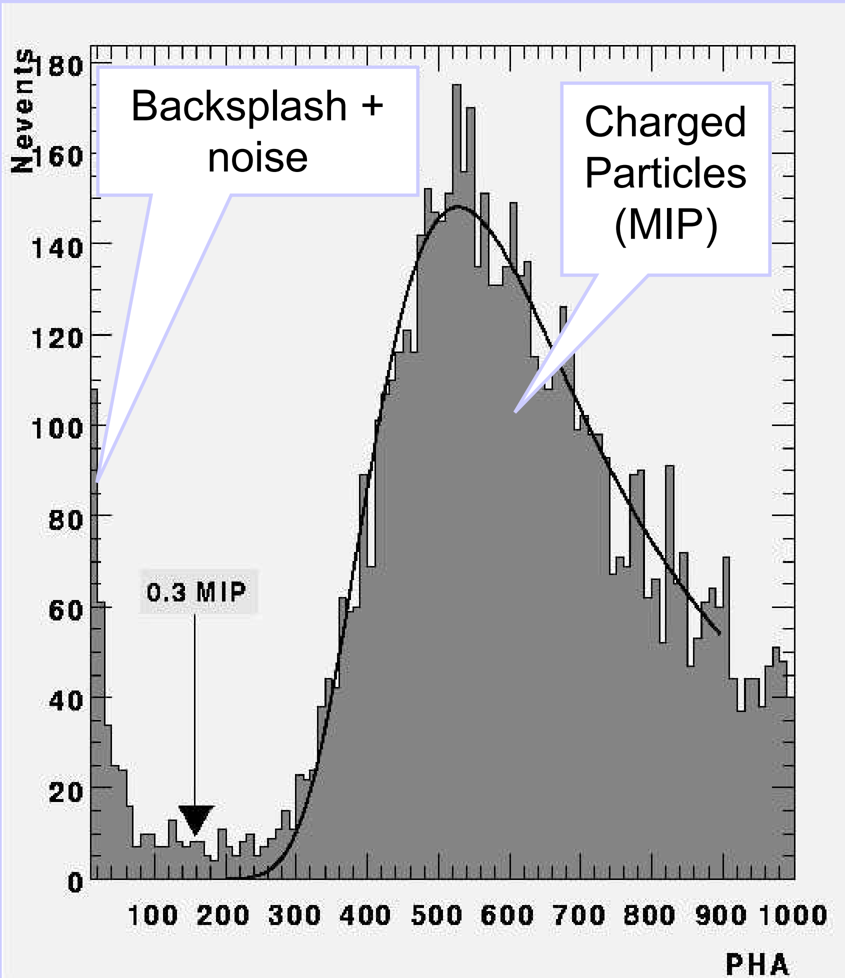
Anti-Coincidence Detector (NASA GSFC)



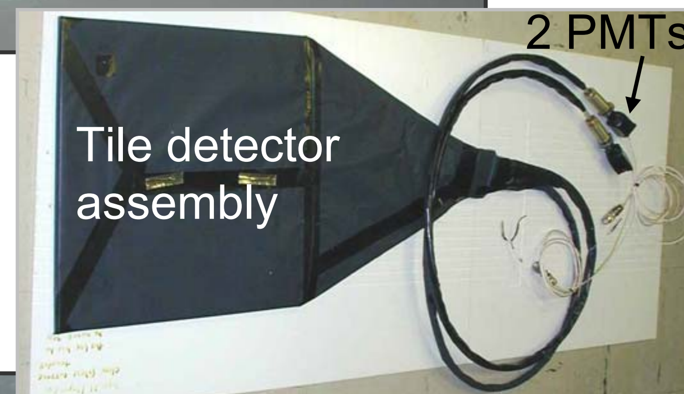
Presently located at SLAC.

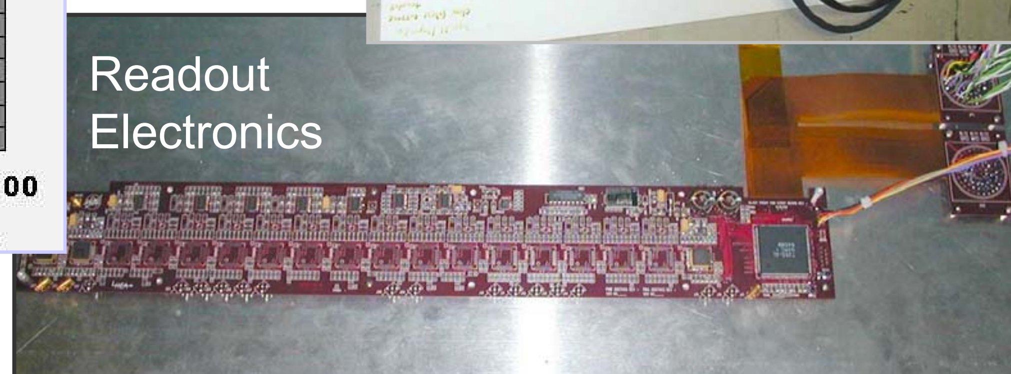
Integration into the instrument is immanent.

Anti-Coincidence Detector

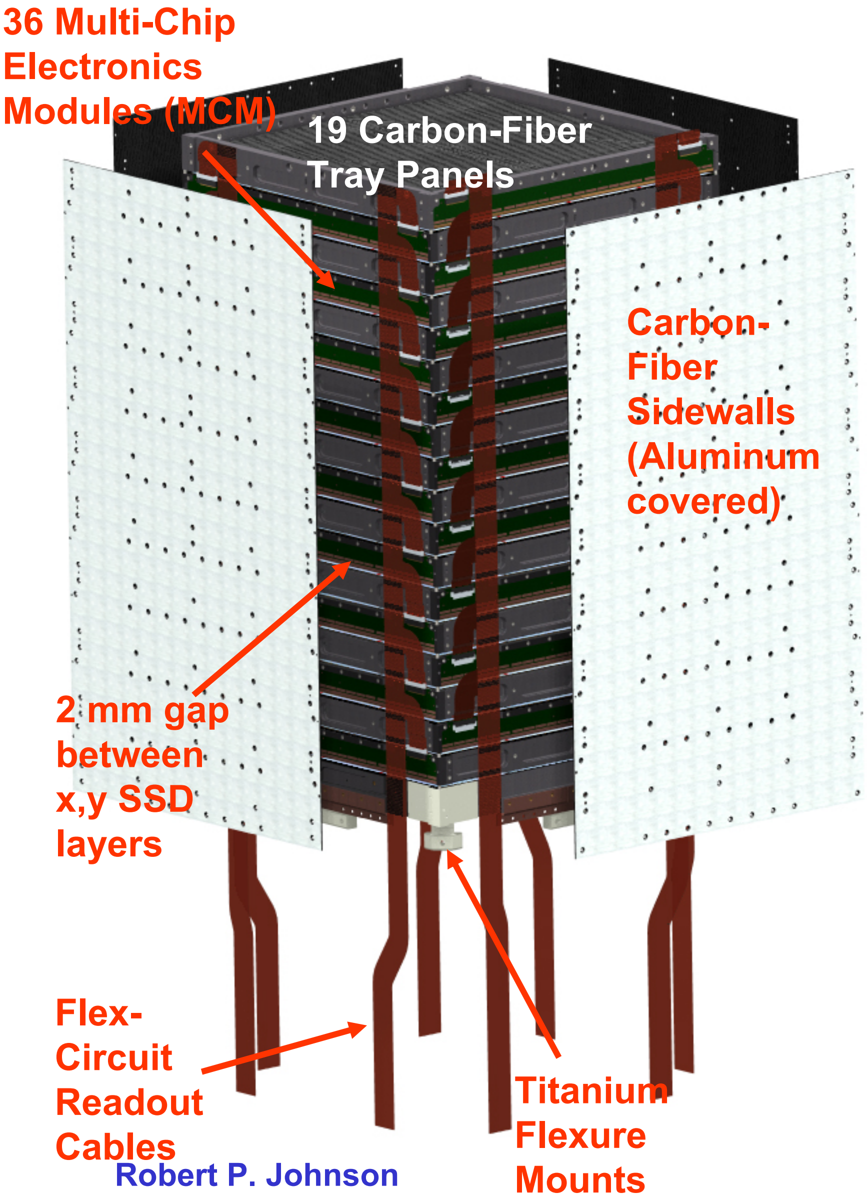


Threshold setting of 0.3 MIP achieves the required efficiency (>0.9997) with low noise.





Silicon-Strip Tracker/Converter

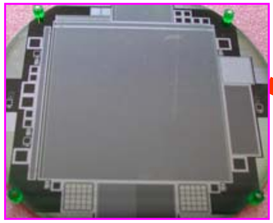


- Carbon-composite structure supports 18 *x* and 18 *y* layers of silicon-strip detectors and 16 layers of tungsten converter foils.
- 36 custom readout electronics boards, each with 1536 amplifier channels, mount on the sides of the panels to minimize inter-tower dead space.

Tracker Production Overview

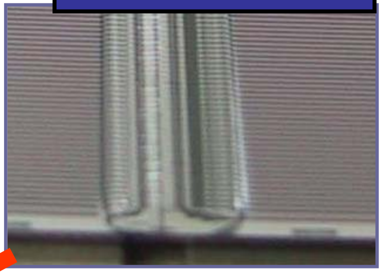
Module Structure Components:
Composite Sidewalls: Italy (Plyform)
Other parts: SLAC

SSD Procurement, Testing
Japan, Italy (HPK)



10,368

SSD Ladder Assembly, Italy (G&A, Mipot)

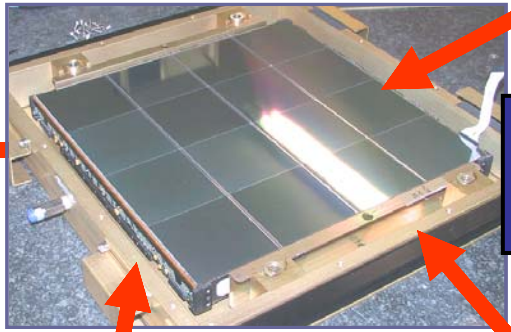


2592

Tracker Module Assembly, Italy

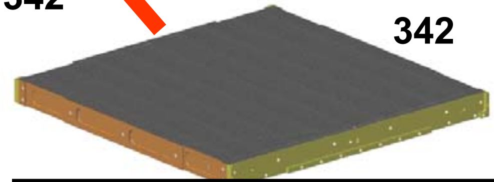
18 (incl. 2 spare)

Environmental Test, Italy (Alenia-Spazio)



342

Tray Assembly and Test, Italy (G&A)

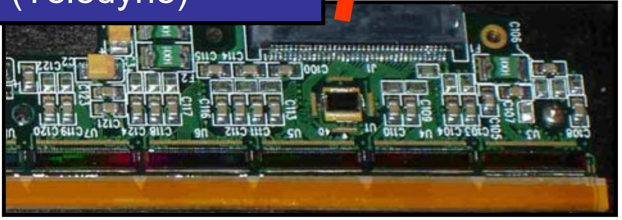


342

Composite panel assembly, Italy (Plyform)

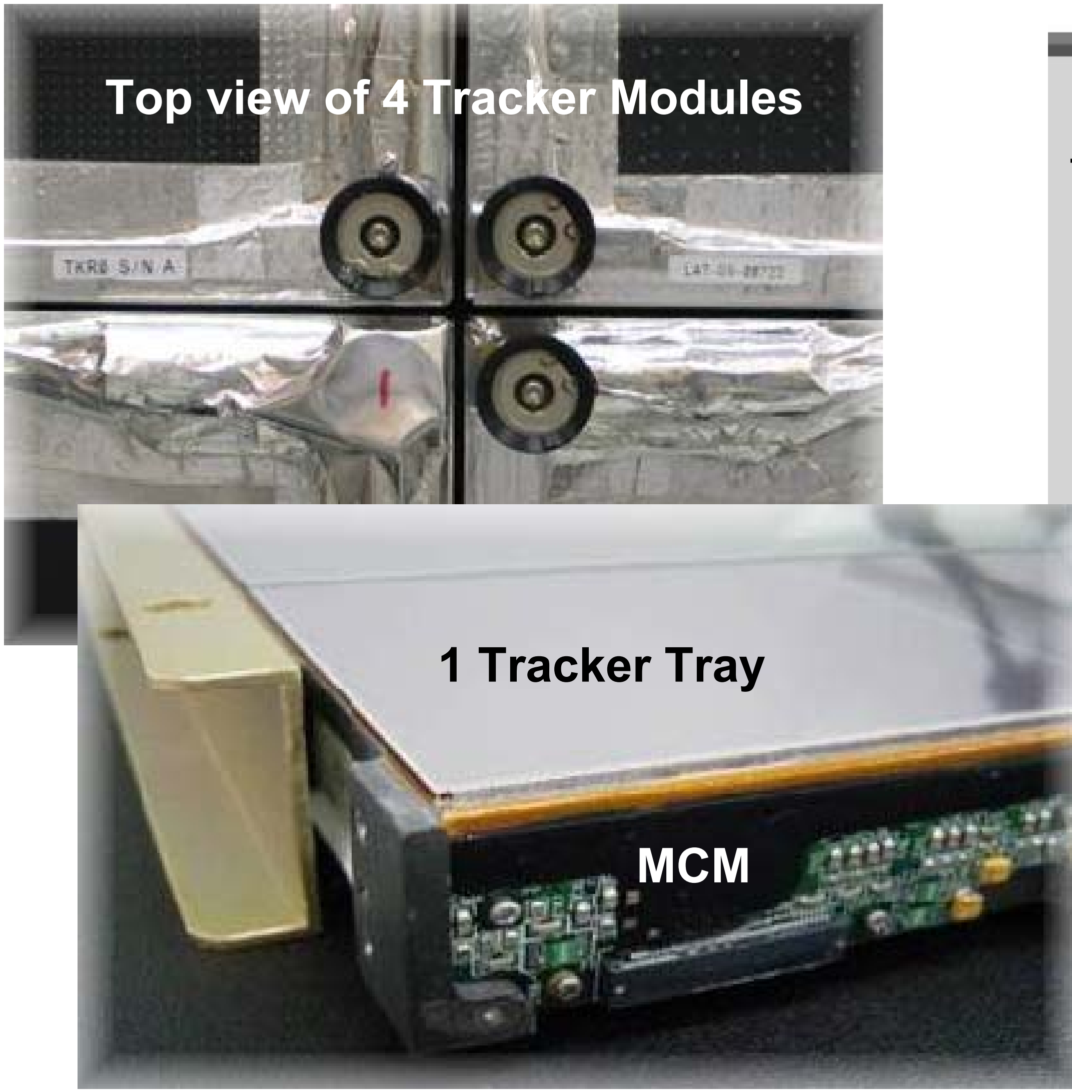
Electronics Fabrication, burn-in, & Test, UCSC, SLAC (Teledyne)

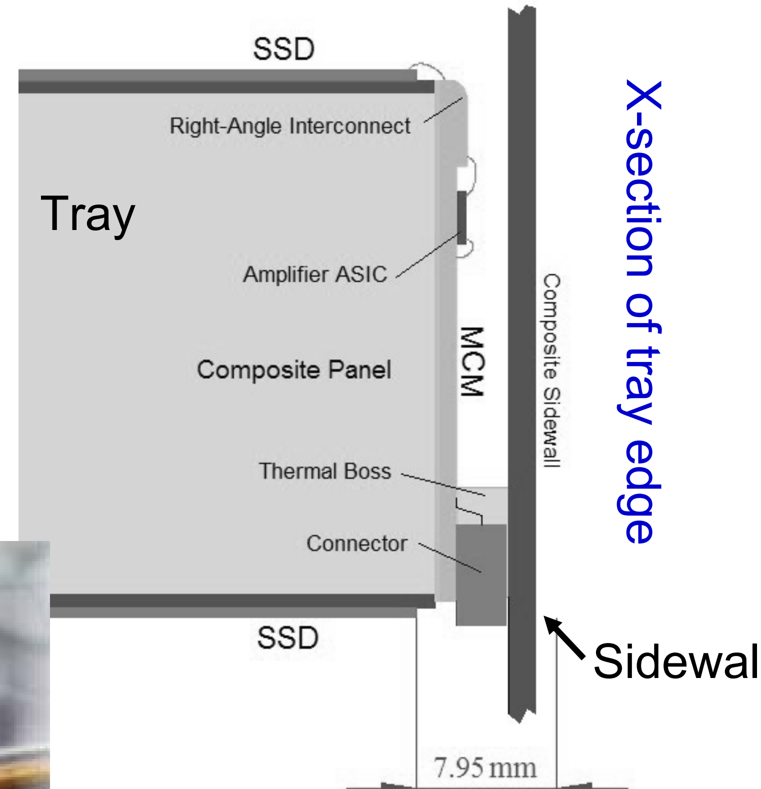
648



Readout Cables
UCSC, SLAC
(Parlex, Pioneer)

Tracker Mechanical Fabrication Challenges



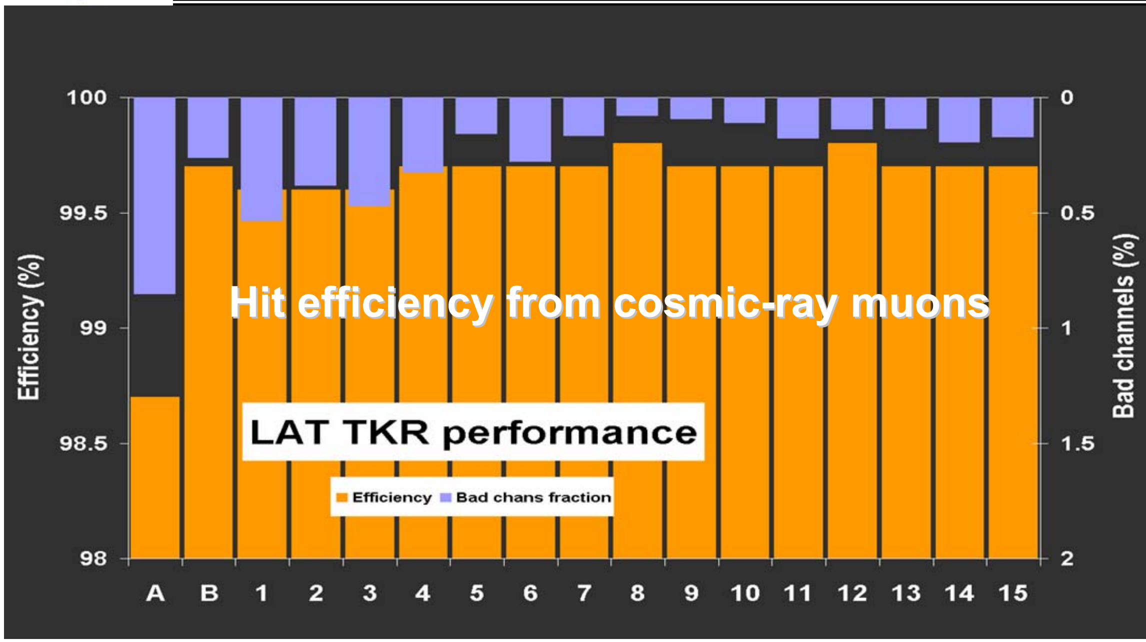


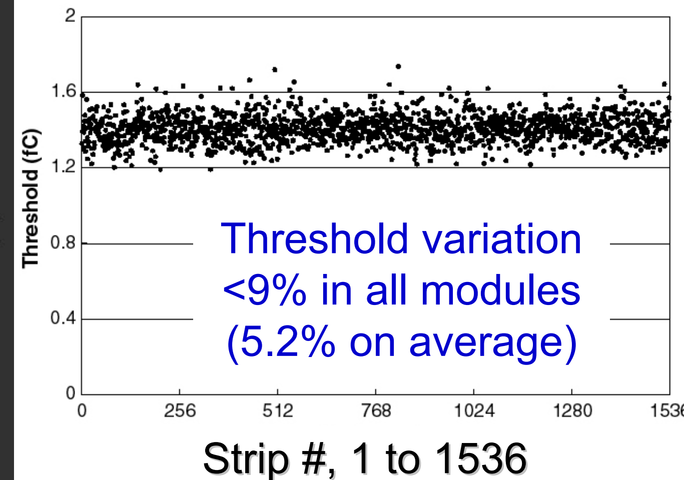
Right-angle interconnect

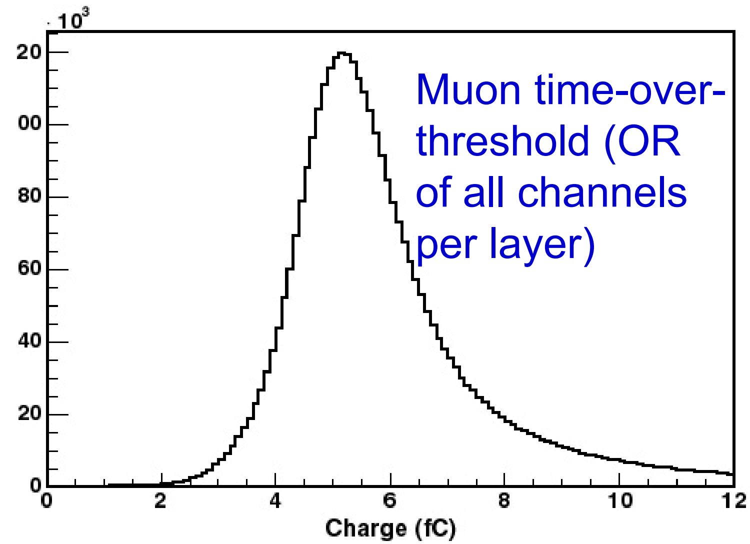
Very tight space for electronics

High precision carbon-composite structure to maintain 2.5 mm gaps between modules

Tracker Performance



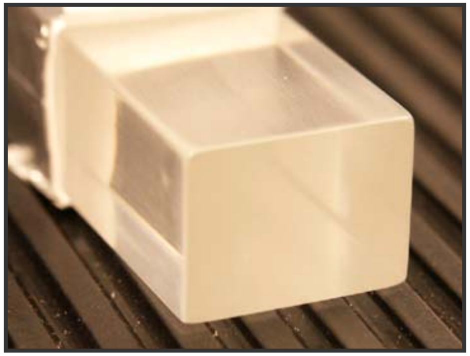




- Hit efficiency (in active area) >99.5%
- Overall Tracker active area fraction: 89.4%
- Noise occupancy $<5\times10^{-7}$
- Power consumption 158 W (178 μW/ch)
- Time-over-threshold 43% FWHM

Calorimeter Production Overview

1728

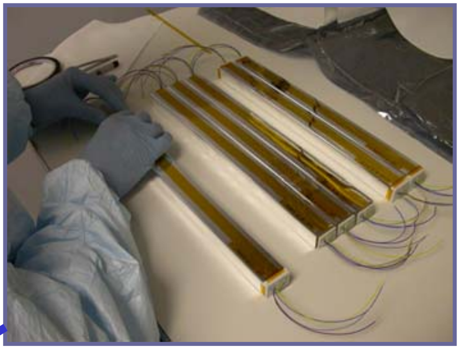


CsI Crystals (Sweden)

3456

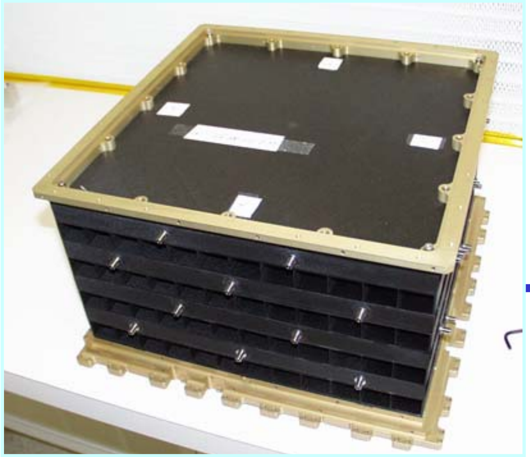
Photo-Diodes (HPK)

1728



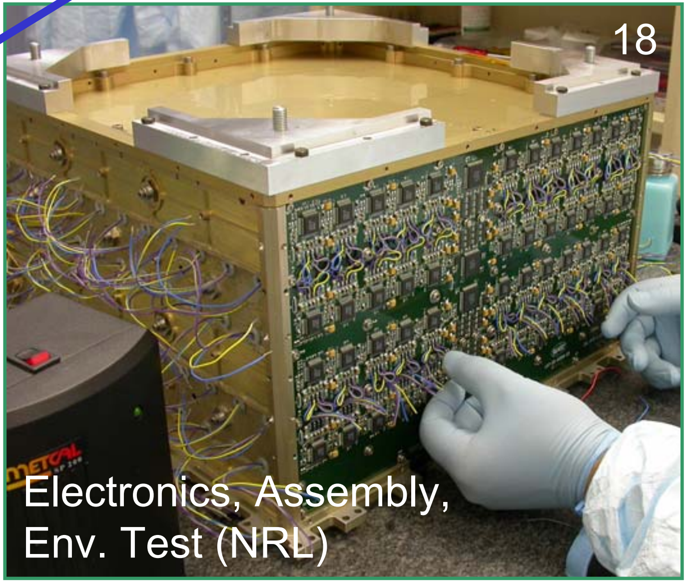
Detector Assembly (NRL/Swales)

18



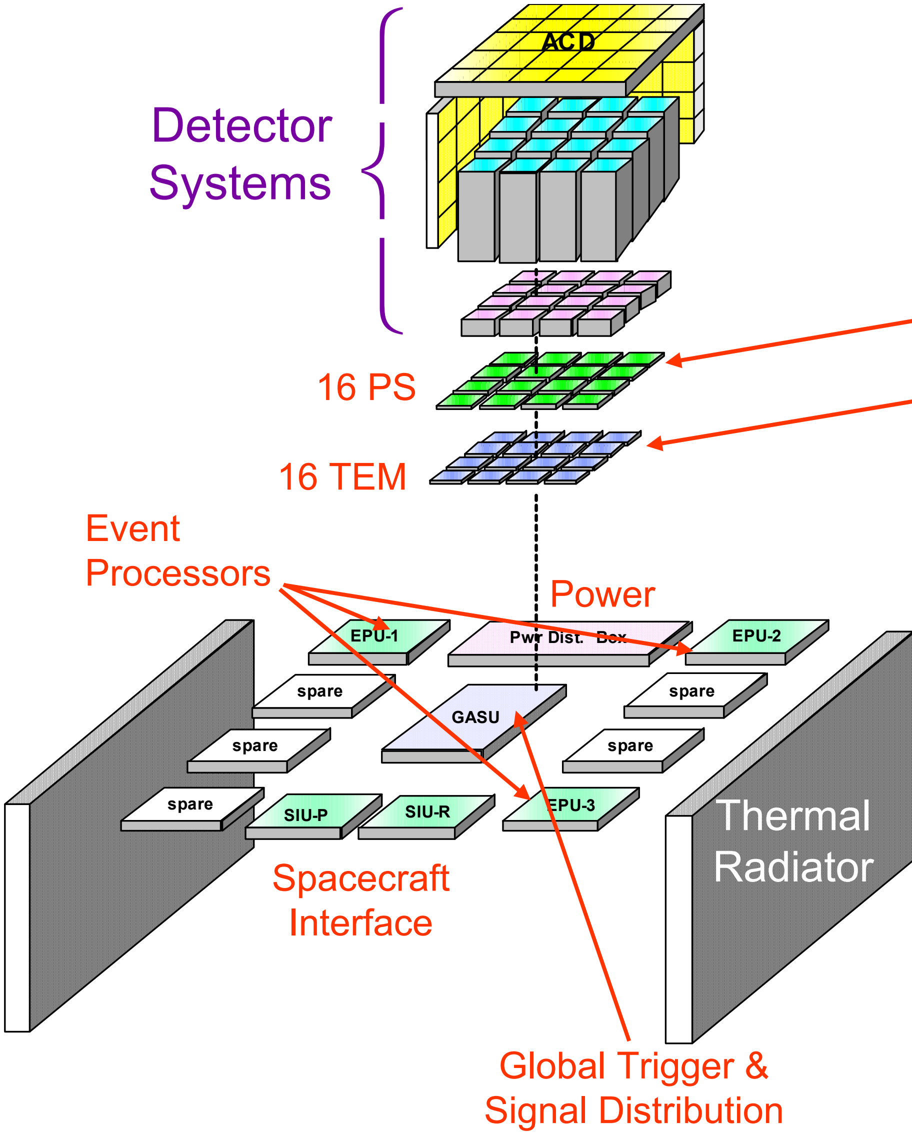
C-Composite Structure (France)

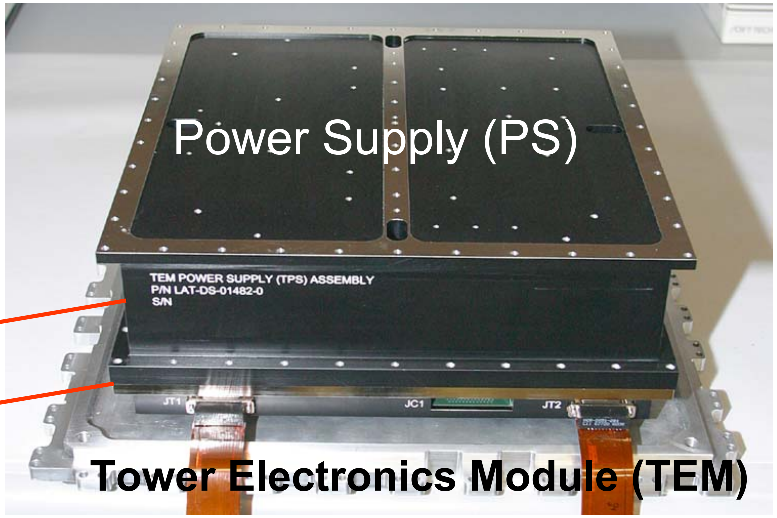
18

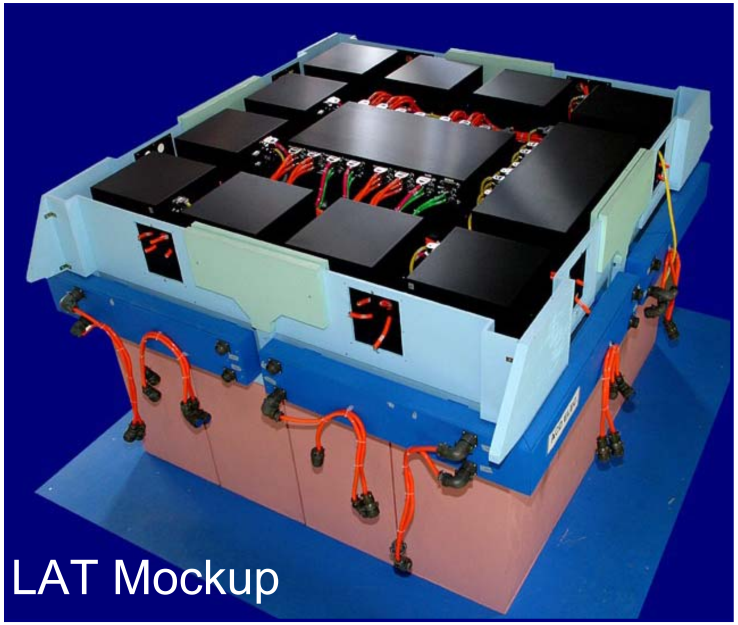


Electronics, Assembly, Env. Test (NRL)

Data Acquisition Electronics (SLAC)

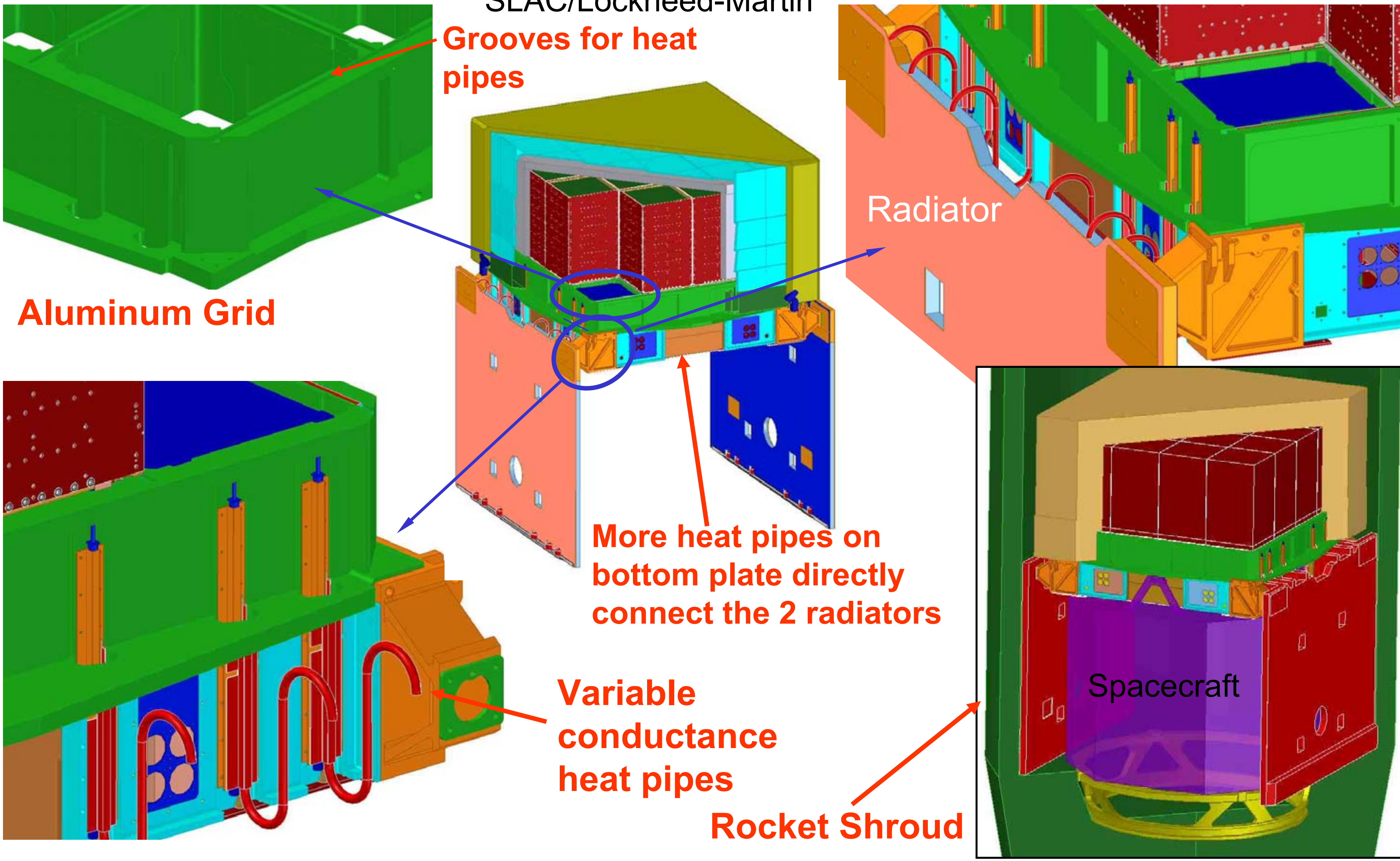






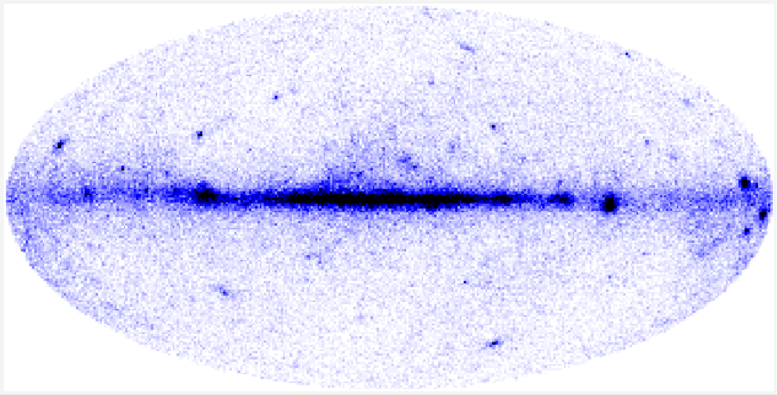
LAT Structural/Thermal Design

SLAC/Lockheed-Martin

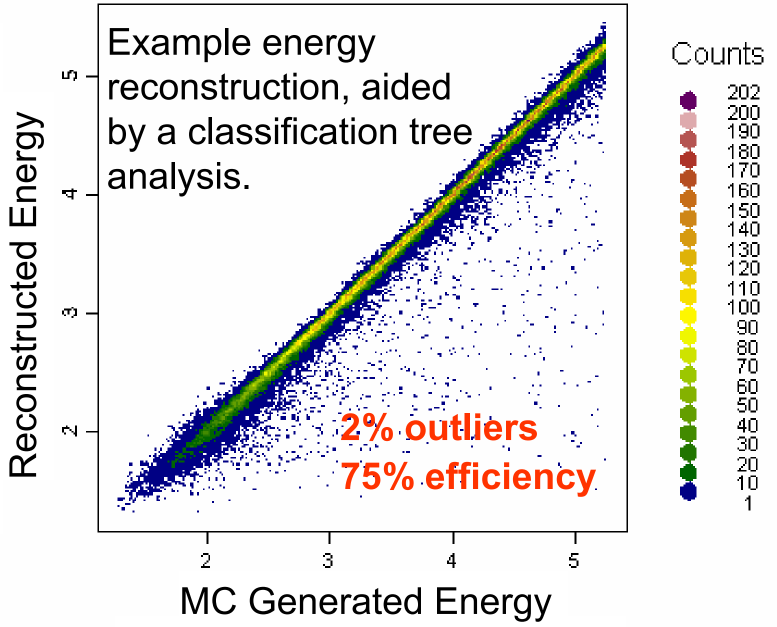


LAT Software Activities

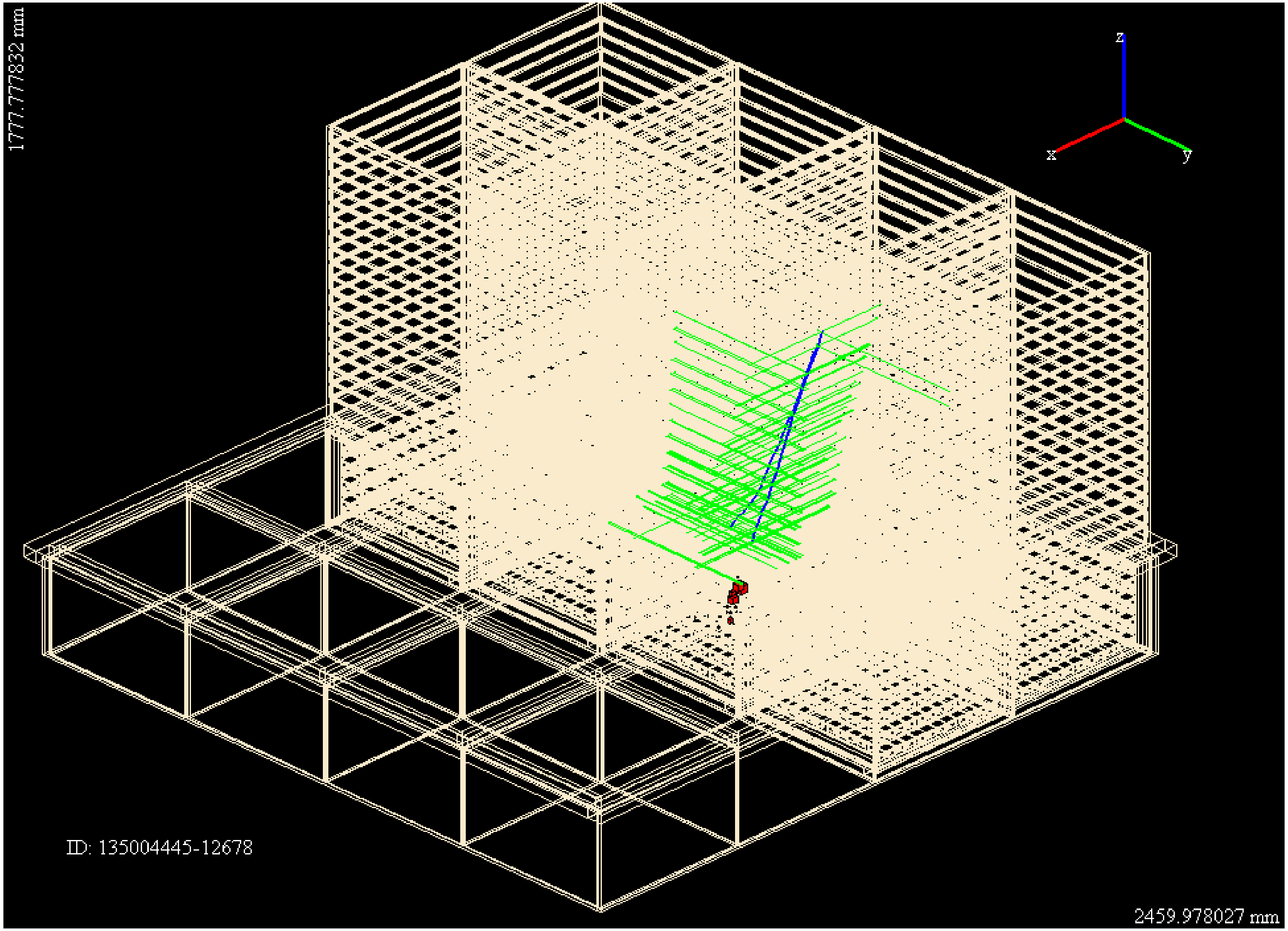
- Ground support
  - Subsystem fabrication (done)
  - LAT integration and test
  - Spacecraft simulation
- Flight software
  - Support instrument operation on ground and in orbit
  - 2nd & 3rd level triggers (filters)
- Offline software
  - Event simulation
  - Event reconstruction
    - PSF optimization
    - Energy optimization
    - Background rejection
  - Instrument science operations
  - Science tools



"Data Challenge" simulation of the full sky (here 1 day; working on 1 month)



Cosmic-Ray Gamma Conversions in 8 Towers



Conclusions

- **All LAT detector systems are (finally!) completely fabricated, with all 16 towers installed.**
- **The LAT will be assembled and functionally tested by January.**
- **Environmental testing will be completed at NRL by summer, and then the instruments will go to Arizona to be integrated with the spacecraft.**
- **Launch in August 2007.**
- **5 to 10 years of operations.**
  - **All of you will have access to the data after the 1st year!**
- ***With GLAST and the new generation of ground based telescopes working together, we can look forward to a new and exciting era of discovery and advances in high-energy astrophysics!***